CLAIMS

I claim:

1. A method of reconfiguring pipeline sizes in order to relieve congestion in a packet-based network, said network comprising a plurality of gateway nodes having data to be transferred therebetween, and utilizing a concept of virtual pipelines between nodes (gateway) of said network, said pipelines comprising one or more channels, said method comprising the steps of:

(1) identifying a first set of virtual pipelines for which traffic exceeds a predetermined threshold;

(2) for each virtual pipeline in said set, determining pipeline size that would cause said traffic through said pipeline to not exceed said predetermined threshold; and

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(3) for each pipeline in said first set that can be increased in size, increasing its size to said size determined in step (2).

2. The method set forth in claim 1 wherein said predetermined threshold is a call blocking ratio and wherein step (2) comprises determining a minimum pipeline size that would reduce the call blocking ratio for said pipeline below said predetermined threshold based on call arrival rate at said virtual pipeline and average holding time per call.

3. The method set forth in claim 2 wherein said minimum pipeline size is expressed as a number of channels, M, in said pipeline and wherein step (2) comprises determining a number of channels M by;

$$B_M(\lambda_i / \mu) = \frac{(\lambda_i / \mu)^M / M!}{\sum_{n=0}^{M} (\lambda_i / \mu)^n / n!}$$

wherein

$$\rho(t) = \lambda((t) / \mu(t)$$

or

$$\rho'(t) = \lambda(t) - \rho(t) / \mu(t)$$

4. The method set forth in claim 3 wherein $\rho(t) = \lambda((t) / \mu(t)$ is used when call rate through said pipeline has been historically increasing and $\rho'(t) = \lambda(t) - \rho(t)\mu(t)$ is used when call rate through said pipeline has been historically decreasing.

5. The method set forth in claim 3 further comprising the step of:

(3) for each pipeline in said first set that can be increased in size, increasing its size to said size determined in step (2).

6. The method set forth in claim 1 further comprising the steps of:

(4) for each pipeline that cannot be resized in accordance with step (3), determining if a path exists that can accommodate a pipeline of said size determined in step (2); and

(5) for each pipeline for which a path exists that can accommodate a pipeline of said size determined in step (2), creating a pipeline having said size, and directing all new channels between the corresponding gateway nodes through said newly created pipeline.

7. The method set forth in claim 6 further comprising the steps of:

(6) deleting each pipeline in said second set for which a new pipeline was created in step (5) when no channels are utilizing said pipeline.

8. The method set forth in claim 7 further comprising the steps of:

(7) for each pipeline in said first set that cannot be resized in step (3) and for which an alternate path is

determined in step (4) not to exist, determining if a pipeline can be created that can accommodate a fraction of said channels in said pipeline by which said pipeline exceeds said threshold;

(8) creating a new pipeline of a size corresponding to said fraction of channels determined in step (7) and directing said fraction of new channels from said pipeline to said new pipeline.

9. The method set forth in claim 7 further comprising the steps of:

(9) identifying a second set of virtual pipelines for which traffic is less than said predetermined threshold; and

(10) for each pipeline in said second set, determining a size of the smallest pipeline that can accommodate the traffic present in that pipeline while satisfying said predetermined threshold.

10. The method set forth in claim 9 further comprising the steps of:

(11) reducing the size of each of said pipelines in said second set that can be reduced in size to said size determined in step (10);

(12) for each pipeline that cannot be resized in accordance with step (11), determining if a path exists that

can accommodate a pipeline of said size determined in step (10); and

(13) for each pipeline for which a path exists that can accommodate a pipeline of said size determined in step (10), creating a pipeline having said size, and directing all new channels between the corresponding gateway nodes through said pipeline.

11. The method set forth in claim 10 further comprising the steps of:

(14) deleting each pipeline in said second set for which a new pipeline was created in step (13) when no channels are utilizing said pipeline.

12. The method set forth in claim 3 wherein said network is an asynchronous transfer mode network.

13. The method set forth in claim 12 wherein said network is used to exchange voice data.

14. The method set forth in claim 13 wherein said network comprises a telephone network.

15. The method set forth in claim 3 wherein said network interconnects a plurality of other networks.

16. The method set forth in claim 15 wherein said other networks comprises time division multiplexed networks.

17. A method of identifying pipeline size reconfiguration parameters in a packet-based network comprising a plurality of gateway nodes having data to be transferred, said network utilizing a concept of virtual pipelines between nodes (gateway) of said network, said pipelines comprising a plurality of channels, said method comprising the steps of:

(1) identifying a set of virtual pipelines for which traffic exceeds a predetermine threshold; and

(2) for each virtual pipeline in said set, determining a number of channels that would cause said traffic through said pipeline to not exceed said predetermined threshold.

18. The method set forth in claim 17 wherein said predetermined threshold is a call blocking ratio and wherein step (2) comprises determining a minimum pipeline size that would reduce the call blocking ratio for said pipeline below said predetermined threshold based on call arrival rate at said virtual pipeline and average holding time per call.

19. The method set forth in claim 18 wherein said minimum pipeline size is expressed as a number of channels, M,

in said pipeline and wherein step (2) comprises determining a number of channels M by;

$$B_M(\lambda_i / \mu) = \frac{(\lambda_i / \mu)^M / M!}{\sum_{n=0}^{M} (\lambda_i / \mu)^n / n!}$$

wherein

$$\rho(t) = \lambda((t) / \mu(t)$$

or

$$\rho'(t) = \lambda(t) - \rho(t)\mu(t)$$

20. The method set forth in claim 19 wherein equation 2a is used when call rate through said pipeline has been historically increasing and equation 2b is used when call rate through said pipeline has been historically decreasing.

21. The method set forth in claim 19 further comprising the steps of:

(9) identifying a second set of virtual pipelines for which traffic is less than said predetermined threshold; and

(10) for each pipeline in said second set, determining a size of the smallest pipeline that can accommodate the traffic present in that pipeline.

22. The method set forth in claim 21 further comprising the step of:

(10) calculating a peak cell rate corresponding to said number of channels determined in step (2).

23. The method set forth in claim 20 wherein said network is an asynchronous transfer mode network.

24. The method set forth in claim 23 wherein said network is used to exchange voice data.

25. The method set forth in claim 24 wherein said network comprises a telephone network.

26. The method set forth in claim 20 wherein said network interconnects a plurality of other networks.

27. The method set forth in claim 26 wherein said other networks comprises time division multiplexed networks.

28. The method set forth in claim 27 wherein said other networks comprise public service telephone networks.

29. An apparatus for reconfiguring pipeline sizes in order to relieve congestion in a packet-based network, said network comprising a plurality of nodes having data to be

transferred therebetween, and utilizing a concept of virtual pipelines between said nodes (gateway), said pipelines comprising one or more channels, said apparatus comprising:

means for identifying a first set of virtual pipelines for which traffic exceeds a predetermined threshold;

means for determining, for each virtual pipeline in said first set, a pipeline size that would cause said traffic through said pipeline to not exceed said predetermined threshold; and

means for increasing, for each pipeline in said first set that can be increased in size, said pipeline's size to said size determined by said means for determining.

30. The apparatus set forth in claim 29 further comprising:

means for determining, for each pipeline that cannot be resized, if a path exists that can accommodate a pipeline of said determined size; and

means for creating, for each pipeline for which a path exists that can accommodate a pipeline of said determined size, a virtual pipeline having said size, and directing all new channels between the corresponding nodes (gateways), through said pipeline created in step.

31. The apparatus set forth in claim 30 further comprising:

means for deleting each pipeline in said second set for which a new pipeline was created when no channels are utilizing said pipeline.

32. The apparatus set forth in claim 21 further comprising:

means for deciding, for each pipeline in said first set that cannot be resized and for which an alternate path is determined not to exist, if a pipeline can be created that can accommodate a fraction of said channels in said pipeline by which said pipeline exceeds said threshold;

means for creating a new pipeline of a size corresponding to said fraction of channels and directing said fraction of new channels from said pipeline to said new pipeline.

33. The apparatus set forth in claim 29 wherein said predetermined threshold is a call blocking ratio and wherein said means for determining determines a minimum pipeline size that would reduce the call blocking ratio for said pipeline below said predetermined threshold based on call arrival rate at said virtual pipeline and average holding time per call.

34. The apparatus set forth in claim 33 wherein said minimum pipeline size is expressed as a number of channels, M, in said pipeline and wherein said means for determining determines a number of channels M by;

$$B_M(\lambda_i / \mu) = \frac{(\lambda_i / \mu)^M / M!}{\sum_{n=0}^{M} (\lambda_i / \mu)^n / n!}$$

wherein

$$\rho(t) = \lambda((t) / \mu(t)$$

or

$$\rho'(t) = \lambda(t) - \rho(t)] / \mu(t)$$

35. The apparatus set forth in claim 34 wherein equation 2a is used when call rate through said pipeline has been historically increasing and equation 2b is used when call rate through said pipeline has been historically decreasing.

36. The apparatus set forth in claim 34 further comprising:

means for identifying a second set of virtual pipelines for which traffic is less than said predetermined threshold; and

means for determining, for each pipeline in said second set, a size of the smallest pipeline that can accommodate the traffic present in that pipeline.

37. The apparatus set forth in claim 36 further comprising:

means for reducing the size of each of said pipelines in said second set that can be reduced in size to said smallest size;

means for determining, for each pipeline that cannot be resized, if a path exists that can accommodate a pipeline of said smallest size; and

means for creating, for each pipeline for which a path exists that can accommodate a pipeline of said smallest size, a virtual pipeline having said size, and for directing all new channels between the corresponding nodes (gateways) through said pipeline.

38. The apparatus set forth in claim 37 further comprising:

means for deleting each pipeline in said second set for which a new pipeline was created when no channels are utilizing said pipeline.